Advancing Biofuels Research
NCERC at SIUE

Pilot Plant Options

1. Introduction

The Pilot Plant at NCERC offers a wide variety of options for processing biomass and other materials. The options defined here reflect a standard corn-to-ethanol process; however, the pilot plant is designed to be “plug and play” and can be reconfigured or modified for other nonstandard processes. With a wide assortment of additional equipment and technologies available for custom configurations, the Center can typically accommodate any special requests for your particular project. Please contact Steven Ward at sward@ethanolresearch.com to learn more about the NCERC’s process flexibility and additional options.

2. Standard Procedure

The process starts with a feedstock that is either hammer milled, fractionated or externally prepared. When hammer milled or fractionated, the material passes through a corn cleaning system. The corn-cleaning system includes a destoner, which removes heavies and fines, and a scalper/screener, which removes large particles and more fines. The cleaned corn is fed into the hammer mill or fractionation system from a loss-in-weight feeder, which controls its feed rate to the system.

The flour is fed into the slurry mixer where it is mixed with hot process water and then transported into the slurry tank. A dose of alpha amylase enzyme is added to the slurry tank to control the slurry viscosity. The slurry tank is equipped with online level, temperature, pH, and density monitoring. The temperature of the slurry tank is maintained by a shell-and-tube heat exchanger on the recirculation line, and pH is maintained by addition of sulfuric acid or aqueous ammonia.

Slurry is pumped to a JetCooker or Pick heater where the temperature is instantaneously raised above the boiling point of water to convert the starch into a form that is more accessible to enzymatic hydrolysis. The elevated temperature is maintained under pressure as the slurry is pumped through a hold tube.

After the hold tube, the product falls through a flash vessel and into the liquefaction tank. An additional dose of alpha amylase enzyme is added to the recycle line of the liquefaction tank. The effluent from the liquefaction tank is pumped to a heat exchanger which cools the mash to the fermentation temperature.

Cooled mash is pumped into one of the four fermentors until the target fill mass is reached. After a fermentor is filled, it is treated as an individual batch reactor and is held until fermentation is complete, at which time the entire fermentor contents is transferred to the beer well. Carbon dioxide is vented from the fermentors. Yeast, glucoamylase, urea, and other required materials are added to each fermentor. Fermentation begins when the yeast is added to the fermentor.

When the fermentor is finished the beer is pumped to the beer well. Beer is processed through distillation where it is separated into pure ethanol and whole stillage. The distillation system runs under pressure and consists of three separation columns, two molecular sieve units, and several heat exchangers. Beer enters the degas column and whole stillage exits the beer column. Whole stillage is pumped to the decanter centrifuge. Two-hundred-proof ethanol exiting from the molecular sieves is pumped for storage to the ethanol storage tank.

Whole stillage is separated into a solids fraction (wet cake) and a liquid fraction (thin stillage) by the decanter centrifuge. Wet cake falls into the dryer mixer while thin stillage is sent to a storage vessel. Thin stillage from the storage vessel is used to fill the evaporator on a continuous basis. The evaporator concentrates the solids in the thin stillage from about 5% (w/w) dry solids to about 30 to 35% (w/w) dry solids. Once the syrup reaches the desired dry solids concentration, it is transferred to the syrup tank where it is stored until it is applied to the material in the dryer.

The inlet to the Davenport rotary drum dryer contains a mixture of recycled DDGS, syrup, and wet cake with a moisture content of about 30% (w/w). The dryer reduces the moisture to 10-12%. Approximately 80% of the material that exits the dryer is pneumatically conveyed to DDGS storage while the remaining 20% is recycled back into the dryer after the syrup and wet cake addition.

3. Pilot Plant Parameters and Options

Options for each phase of the process are outlined in the tables below. These tables list our most typical protocol settings; however, the Client can specify desired amounts for most variables.

A. Feedstock

Variable	Options		
Substrates	Corn, milo, barley, sugar cane juice, sweet sorghum juice, food residues etc.	Cellulosic feedstock (150L and 1500L fermentations)	Client-provided
Grain preparation	Hammer milled	Dry Fractionated	Client-provided
Grain grind size (hammer milled)	Client-specified		
Fractionation adjustments	Client-specified		

B. Slurry and Liquefaction

Variable	Options		
Slurry Preparation Rate	2.0-4.0 gpm (7.6-15.1 lpm)		
% Total solids	10 – 32% w/w		
Alpha-amylase enzyme	Manufacturer recommended dose	Client-specified	
Water source for slurry	City water	Waste water, stillage or other waste stream	
Slurry Tank Volume	0-90 gallons (0-340 liters)		

Slurry Tank Temperature	<190F (88C)		
Slurry Heater	Hydro-Thermal JetCooker	Pick Heater	None
Slurry Heater Temperature	<260F (127C)		
Liquefaction volume	0-500 gallons (0-1893 liters)		
Liquefaction temperature	Enzyme-specific (e.g. 185F, 85C)		
Alpha-amylase enzyme	Manufacturer recommended dose	Client-specified	
Fermentation temperature	>85F (29C)		

C. Fermentation

Variable	**Options**		
Fermentation volume	1500-5500 gallons (5678-20820 liters)		
Fermentation fill temperature	Fermentation temperature	Client-specified	
Gluco-amylase enzyme	Manufacturer recommended dose	Client-specified	
Nitrogen source (i.e. urea)	500 ppm nitrogen	Client-specified	
Yeast nutrients	Client-specified		
Yeast	Hydrated yeast (in warm water), 10 – 20 million cells/ml	Client-specified	
Antibiotic	0.5 ppm	Client-Specified	

Fermentation Temperature	>85F (29C)		
Fermentation agitation	3-34 rpms		
Fermentation aeration	Client-Specified		
Fermentation duration time	48 – 72 hours		

D. Distillation

Variable	Options	
Distillation feed rate[1]	2-5 gpm (7.6-18.9 lpm)	If you have interest in using distillation in a manner different than standard processing please contact us so we can discuss in further detail.
Ethanol proof	> 198.4	
Reboiler temperature	235F (113C)	
Condenser temperature	177F (81)	

[1]Distillation feed rate is based on percentage of ethanol in the feed material

E. Centrifuge

Variable	Options	
Centrifuge feed rate	2-35 gpm (7.6-132 lpm)	The standard centrifuge at the NCERC is a Centrisys CS10-4 decanter centrifuge. The NCERC is equipped to either rent to use a client owned centrifuge in place or in conjunction with the Centrisys centrifuge.
Centrifuge bowl speed	2000-5000 rpms	
Centrifuge differential speed	3-20 rpms	
Weir plates	adjustable	

F. Evaporation

Variable	Options		
Pressure	2.0-14.7 psig (103-760 torr)		
Volume	300 or 700 gallons (1136 or 2650 liters)		
Evaporation rate	0-1500 lbs/hr		

G. Drying

Variable	Options		
Dryer feed rate	200 lbs/hr at 65% moisture		
Syrup application rate	Client-Specified		
Dryer exit moisture	10-12%		

2. Mass Balance

The NCERC pilot plant is equipped with an array of equipment that is used for mass balance data. The mass balance starts with the incoming feedstock and ends with the products that are produced. In addition to the overall mass balance on the system every step of the process also has inline mass balance measurements where each system can also be individually analyzed.

3. Cost

The cost of an experimental run in the pilot plant depends on many variables. Once the scope of the trial is fully understood a price can be quoted for the work.